



The eel genus *Macrocephenchelys* (Anguilliformes: Congridae) in Taiwan, with description of a new species

JAMES LIN¹, KWANG-TSAO SHAO² & DAVID G. SMITH^{3*}

¹Department of Aquaculture, National Taiwan Ocean University, Pei-Ning Road 2, Keelung, Taiwan

²Biodiversity Research Center, Academia Sinica, Academia Road 128, Section 2, Nankang, Taipei, Taiwan

³Smithsonian Institution, Museum Support Center, 4210 Silver Hill Road, Suitland, MD, USA

⁴Corresponding author. E-mail: smithd@si.edu

Abstract

The congrid eel genus *Macrocephenchelys* in Taiwan is reviewed. Three species are recognized. *Macrocephenchelys brachialis* was originally described from Indonesia and is also known from Taiwan, Madagascar, and Vanuatu; it is common in Taiwan but known from few specimens elsewhere. *Macrocephenchelys brevirostris* was described from Taiwan, where it is common; its occurrence outside Taiwan is uncertain. *Macrocephenchelys nigriventris* **sp. nov.** is described here from 28 specimens collected in Taiwan. *Macrocephenchelys brachialis* is distinguished from the other two species by its more elongate body, more posterior dorsal-fin origin (behind tip of pectoral fin), shorter head (less than 10% total length), presence of a supratemporal pore, absence of fleshy papillae dorsally on the head, absence of sensory pits on the abdomen, and more than 170 vertebrae. *Macrocephenchelys nigriventris* is distinguished from *M. brevirostris* by the presence of a patch of black pigment around the anus and adjacent abdomen (absent in *M. brevirostris*), preanal length 24–28% total length (27–34% in *M. nigriventris*), and 128–135 vertebrae (147–154 in *M. brevirostris*). The only other species currently recognized is *M. soela* from Australia; it is distinguished from all the others by the more anterior origin of the dorsal fin, over the middle of the pectoral fin (vs. over or behind the tip of the pectoral fin).

Key words: Pisces, Teleostei, taxonomy, *Macrocephenchelys nigriventris* **sp. nov.**, Taiwan

Introduction

Macrocephenchelys brachialis was described by Fowler (1934) as the type genus and species of a new family Macrocephenchelyidae, based on two specimens collected from Indonesia. Fowler related the Macrocephenchelyidae to the Leptocephalidae (=Congridae) and Neenchelidae (based on *Neeenchelys*, a genus of Ophichthidae). Gosline (1952) placed the Macrocephenchelyidae in the synonymy of Congridae.

Robins and Robins (1971) described the osteology of *Macrocephenchelys brachialis* and, although recognizing its similarities to the Congridae, chose to retain the Macrocephenchelyidae as a distinct family. Meanwhile, Chen & Weng (1967) described *Rhynchoconger brevirostris*, which they assigned to the Congridae. McCosker *et al.* (1989) placed *Macrocephenchelys* back in the Congridae, and Smith (1989) pointed out that “*Rhynchoconger*” *brevirostris* did not belong in *Rhynchoconger* but rather “may form a bridge to *Macrocephenchelys*.”

Castle (1990) described a new species, *Macrocephenchelys soela*, from eastern Australia; he distinguished it from *M. brachialis* but did not compare it to *brevirostris*, which it actually resembles more. He apparently realized this later and decided that *Macrocephenchelys soela* is a synonym of “*Rhynchoconger*” *brevirostris* (Smith 1994). Smith (2000) formally placed “*Rhynchoconger*” *brevirostris* in *Macrocephenchelys*, and Karmovskaya (2004) recognized *M. soela* as a distinct species based on the more anterior position of the dorsal-fin origin, over the middle of the pectoral fin instead of over or behind the tip of the pectoral fin.

We describe a new species in this paper, bringing the total number now known to four.

Materials and methods

Specimens reported were collected by commercial fishing trawlers mainly in depths of about 100–400 m from Taiwanese waters. They were fixed in formalin and then transferred to 70% ethanol for permanent storage. They are deposited in the following fish collections: National Taiwan Ocean University, Laboratory of Aquatic Ecology, Taiwan (TOU-AE); National Museum of Marine Biology & Aquarium, Taiwan (NMMB-P); Academia Sinica, Biodiversity Research Center, Taiwan (ASIZP); California Academy of Sciences, San Francisco (CAS); and National Museum of Natural History, Washington DC (USNM).

All measurements are in mm. Measurements are straight-line (point to point) and made with dial calipers to the nearest 0.1 mm. The terminology and definitions of morphometric measurements and meristic counts are taken from Böhlke (1989). Vertebrae are counted from radiographs. Illustrations and photographs are by James Lin.

Abbreviations are as follows. Pores: IO, infraorbital; POM, preoperculomandibular; SO, supraorbital; ST, supratemporal; LL, lateral line; PALL, preanal lateral-line; PDDL, predorsal lateral-line; PGLL, pre-gill-opening lateral-line. Fin rays: PADR, preanal dorsal; PR, pectoral-fin. Vertebrae: TV, total; PAV, preanal; PDV, predorsal; PCV, precaudal. Measurements: TL, total length; PAL, preanal length; TR, trunk length; PDL, predorsal length; HL, head length; DGO, depth at gill-opening; DA, depth at anus; IOW, interorbital width; UJ, upper jaw length; LJ, lower jaw length; E, eye diameter; S, snout length; PL, pectoral-fin length.

DNA extractions were performed with the QuickGene DNA tissue kit S (DT-S). And a barcode fragment of approximately 617 base pairs (bp) was amplified from the 5' region of the mitochondrial cytochrome c oxidase subunit I gene (COI) by using the universal primer of Ivanova *et al.* (2007). Sequences (617 bp) were aligned using MUSCLE in MEGA 5. Sequence divergence was calculated using MEGA 5 with the Kimura 2-parameter (K2P) model (10,000 bootstrap) generating a mid-point rooted neighbor-joining (NJ) phenogram to provide a graphic representation of the species divergence (Kimura, 1980; Tamura *et al.*, 2011).

The COI gene sequences were then submitted to Genbank under the accession numbers of MF155273–MF155285.

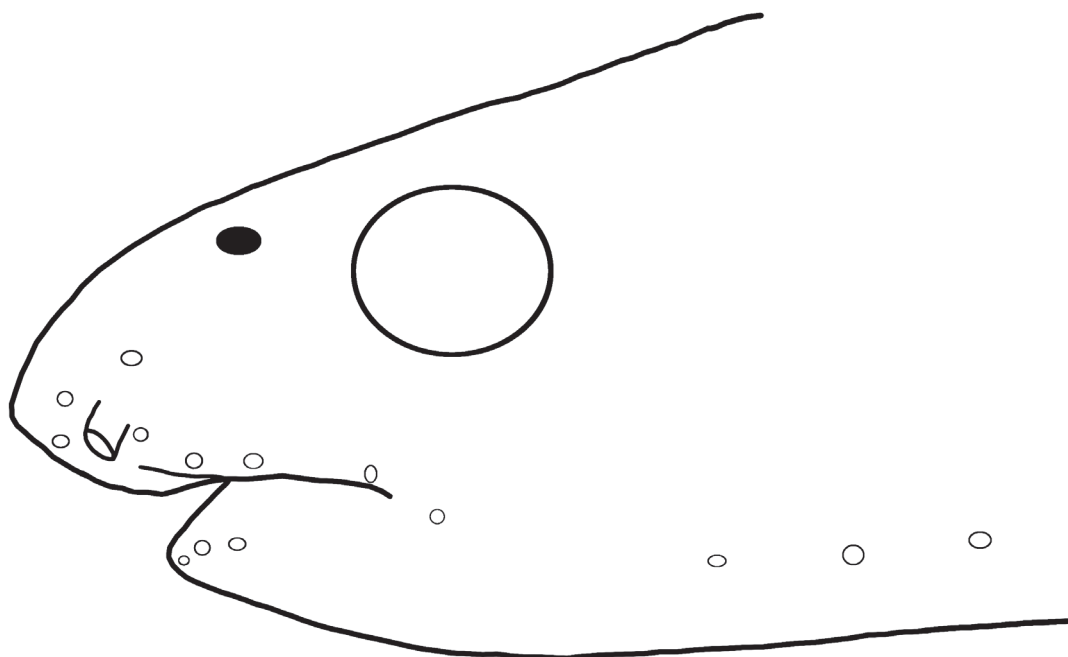


FIGURE 1. Location of head pores in *Macrocephenchelys*.

Family Congridae

Genus *Macrocephenchelys* Fowler, 1934

Macrocephenchelys Fowler, 1934:275 (type species *Macrocephenchelys brachialis* Fowler, 1934, by original designation).

Description. Body moderately elongate to elongate, preanal length less than 35% TL; tail slender but not greatly attenuated. Dorsal fin begins over or slightly behind pectoral fin. Pectoral fin long and well developed, about 40–60% HL. Head moderate; snout short, overhanging lower jaw; upper labial flange absent; anterior part of upper lip containing second and third infraorbital pores somewhat lobe-like in form. Gill opening small. Mouth small, rictus under mid-eye. Anterior nostril tubular, near tip of snout, directed anterolaterally; posterior nostril elliptical, in front of eye, at or slightly above mid-eye level.

Teeth small, conical, multiserial, forming granular patches, embedded in a fleshy matrix.

Head pores small but well developed (Fig. 1). Three SO pores, near tip of snout; first on edge of lip near anterior end of snout; second in front of anterior nostril; third above anterior nostril. Five IO pores; first behind middle of anterior nostril; second and third on lobe-like portion of upper lip; fourth on posterior part of upper lip; fifth behind rictus; no pores behind eye. POM canal with five or six pores, two or three in mandibular section at anterior end of lower jaw and three in preopercular section. One or no ST pores. Small fleshy papillae on lower jaw and sometimes dorsally on head. Some species with small sensory pits on ventral surface of head and abdomen.

Macrocephenchelys brachialis Fowler, 1934

Fig. 2, 3A; Table 1

Macrocephenchelys brachialis Fowler, 1934:277, Fig. 36. (type locality: Makassar Strait, between Borneo and Sulawesi, Indonesia, Albatross station 5667, 2°56'00"S, 118°47'30"E, depth 367 fathoms [671 m]). Robins & Robins, 1971:128 (redescription and osteology); Karrer, 1983:48 (specimen from western Indian Ocean). Ho *et al.*, 2015:148 (Taiwan).

Material examined (93 specimens, 155–765 mm TL): **Holotype:** USNM 92347 (1, 490), Macassar Strait, 2°56'S, 118°47'30"E, 671 m, 29 Dec. 1909. **Paratype:** USNM 93294, (1, 440), Sipadan I., Borneo, 4°06'50"N, 118°47'20"E, 635 m, 28 Sep. 1909. **Non-types:** **Daxi, Yilan, northeastern Taiwan:** ASIZP 59924 (1, 306), 200–400 m, 20 Mar. 1998; ASIZP 60165 (5, 282–422), 200–400 m, 5 Oct. 1997; ASIZP 62538 (1, 472), 308–310 m, 28 Mar. 2003; ASIZP 62539 (1, 457), same; ASIZP 63088 (1, 462), 210–340 m, 2 Apr. 2004; ASIZP 63090 (10, 306–495), 350–650 m, 24 Apr. 2004; ASIZP 63135 (1, 632), 350–650 m, 24 Apr. 2004; ASIZP 63252 (6, 315–428), 21 Mar. 2004; ASIZP 70151 (3, 269–475), 27 Mar. 2004; ASIZP uncat. 2009-9-12 (2, 204–207), Taiwan, no further data; CAS 216685 (2, 380–578), 19 Jul. 2001; NMMP-P20807 (1, 765 mm TL), 20 Jul. 2012; TOU-AE 6687 (1, gravid female, 561 mm TL), 21 Nov. 2012; TOU-AE 6735 (1, gravid female, 530), 10 Jan. 2012; TOU-AE 6736 (1, 396), 10 Jan. 2012; TOU-AE 6737 (1, 385), 10 Jan. 2012; TOU-AE 6743 (1, 369), 26 Sep. 2011; TOU-AE 6744 (1, 387), 26 Sep. 2011; TOU-AE 6745 (1, mature female, 498), 26 Sep. 2011; TOU-AE 6746 (1, mature female, 560), 26 Sep. 2011; TOU-AE 6747 (1, male, 330), 26 Sep. 2011; TOU-AE 7030 (1, mature female, 426), 9 May 2013; USNM 377316 (30, 216–510), 27 Mar. 2004; USNM 391645 (2, 396–415), 8 Dec. 2006. **Dong-gang, Pingtung, southwestern Taiwan:** ASIZP 62315 (4, 213–254), 300 m, 1 Mar. 2001; USNM 399864 (1, 208), 10 Nov. 2009; USNM 401078 (2, 187–247), 14 Nov. 2009. **Dongsha Island, South China Sea:** ASIZP 60166 (1, 512), 15 May 1993. **Taiwan (no further data):** USNM 399949 (1, 262), 2009; USNM 399950 (3, 155–201), 2009; USNM 402415 (1, 201), 2009; USNM 404319 (1, 170+), 2009. **Vanuatu:** MNHN 2014-0935 (1, 210), 14°55'48"S, 166°51'46.8"E, depth 930–1012 m, 13 Oct. 2006.

Diagnosis. *Macrocephenchelys brachialis* is distinguished from the other species by the following characters: body more elongate (DA 2.2–5.9 %TL), more delicate and flexible; head shorter (7.1–9.5 %TL, 25.6–36.2 %PAL, 1.8–2.8 times in trunk); dorsal-fin origin well behind tip of pectoral fin; vertebrae more numerous (173–183); ST pore present; fleshy papillae present on lower jaw but not dorsally on head; sensory pits on ventral surface of head and anterior body absent.

Description. Measurements in %TL: PAL 24.8–31.0, tail 69.8–74.9, TR 16.1–22.6, PDL 14.9–17.9, HL 7.1–9.5, DA 2.2–5.9. In % PAL: TR 63.4–80, PDL 55.4–64.8, HL 25.6–36.2. In % HL: S 11.2–20.5, E 10.0–18.7, IOW 6.9–18.4, UJ 16.0–21.9, LJ 10.4–15.2, GO 3.9–6.7, IB 22.9–46.8, PL 42.4–74.5. Pores: PDL 16–18, PALL 33–36, SO 3, IO 5, POM 5 (2+3), ST 1. Fin rays: PAD 39–42, PR 11–14. Vertebrae: PDV 14–20, PAV 28–38, PCV 45–54, TV 173–183.

Body elongate, dorsal-fin origin behind tip of pectoral fin by a distance about equal to length of pectoral fin. Head smooth, without fleshy papillae dorsally, and without rows of small sensory pits ventrally on head and abdomen. Anterior end of upper and lower lips with fleshy lobes and ridges. Teeth small, conical, multiserial on

maxilla and dentary, rows wider at anterior end; intermaxillary teeth somewhat larger, conical, in about 2 irregular transverse rows; vomerine teeth small, in a short oval patch, reaching less than halfway to end of maxillary tooth row.

Body grey with a hint of pink-purple color; head pink-red in color when fresh, deep-purple when preserved. Smaller specimens with a few small but distinct melanophores at intervals along middle of body, probably remnants of larval pigment.

Maximum size about 800 mm TL.

Distribution. Known from a few widely scattered locations in the Indian Ocean and western central Pacific: east coast of Madagascar; Makassar Strait, Indonesia (holotype); northeastern Borneo, Malaysia (paratype); Taiwan; and Vanuatu. Depth 635–1012 m.

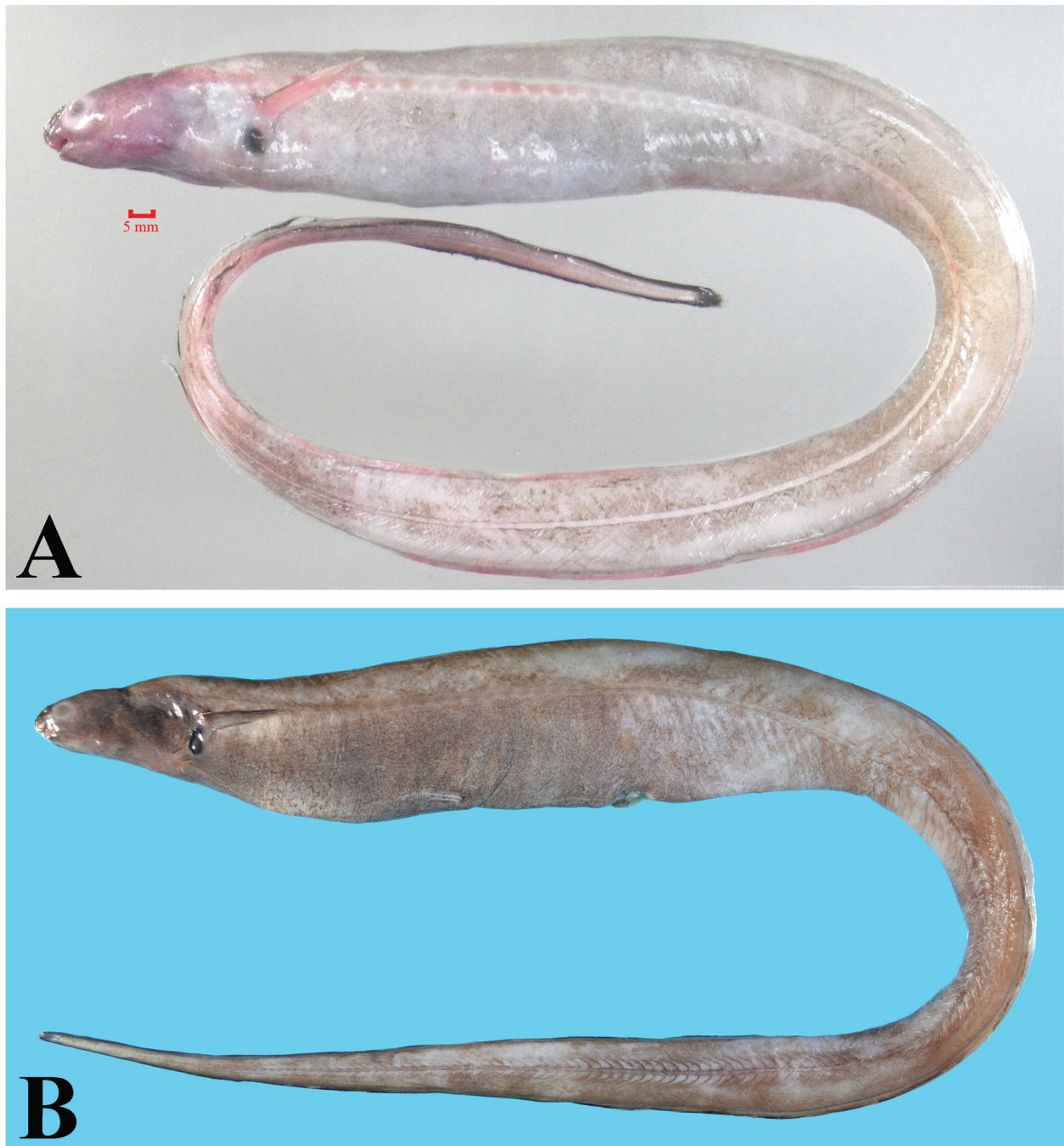


FIGURE 2. *Macrocephenchelys brachialis*, TOU-AE6687, 561 mm TL, B. NMMB-P20807, 765 mm TL.

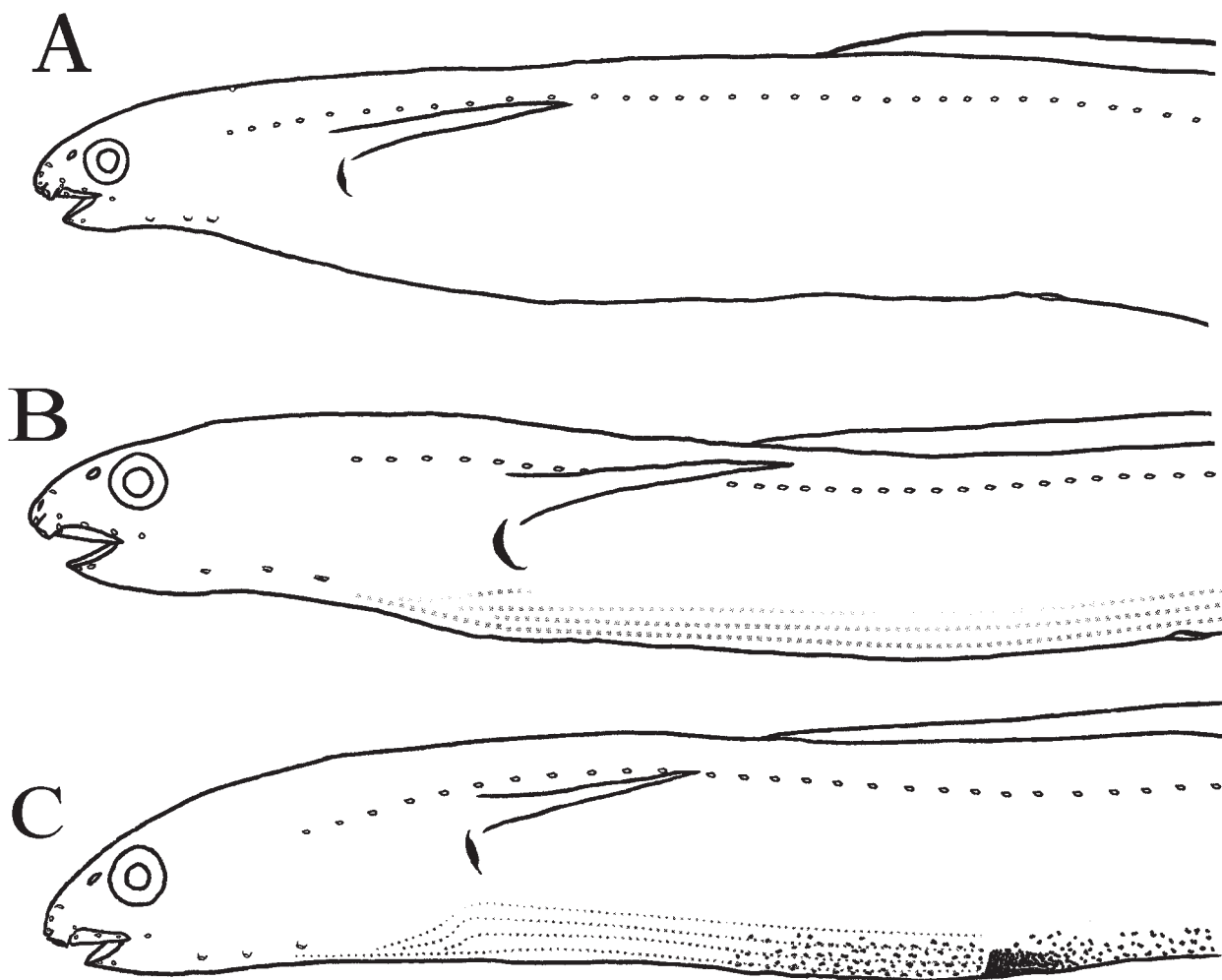


FIGURE 3. Head and anterior body with pores of three species of *Macrocephenchelys*. A. *M. brachialis*. B. *M. brevirostris*. C. *M. nigriventris* sp. nov.

Remarks. The number and placement of the POM pores deserves comment. We counted five of these, all very small, the first two in the mandibular section near the tip of the lower jaw, and the last three in a row in the lower part of the preopercular section before it turns dorsally toward the anterior end of the LL canal. Robins and Robins (1971) described these somewhat differently, from back to front, beginning with two small pores at the upper end of the preopercular canal close to its junction with the LL canal. We saw these two pores, very small and papilla-like, on the left side as illustrated in Robins and Robins (1971: fig. 1), but we did not find them on the right side or in our specimens from Taiwan. They may be anomalous or irregular. What Robins and Robins described as the sixth POM pore located behind the gape we interpret as the fifth IO pore, which is in the same position it occupies in most other congridrids. Robins and Robins described a seventh POM pore “just anterior to the corner of the gape along the nearly transverse lower jaw.” We were unable to find this pore in the holotype or in our specimens.

This is the most distinctive species of *Macrocephenchelys*, with its greatly elongate body, small head, posterior dorsal-fin origin, and the absence of sensory pits ventrally. The fleshy lobes and ridges on the snout are more elaborately developed here than in the other species. This species was originally described from Indonesia and Malaysia, but the great majority of specimens known today are from Taiwan, where it seems rather common in deep water. Taiwan specimens were all collected from markets, and there is no precise information on depth of capture. The holotype and paratype were collected at 635 and 1012 m, which is significantly deeper than the other three known species. The rather flabby and delicate body is characteristic of fishes that live in greater depths. The additional records from Madagascar (Karrer, 1983) and Vanuatu (the present study) suggest that it probably occurs in much of the intervening area as well.

TABLE 1. Morphometric and meristic data of *Macrocephenchelys nigriventris* sp. nov., *M. brevirostris* and *M. brachialis*.

	<i>M. nigriventris</i>		<i>M. brevirostris</i>	<i>M. brachialis</i>
	Holotype	Paratypes		
Total length (mm)	221	153–241 (n=27)	199–460 (n=49)	155–703 (n=92)
% TL				
Preanal length	24.4	24.4–28.0	27.1–33.5	24.8–31.0
Predorsal length	19.0	16.7–19.8	15.9–19.7	14.9–17.9
Head length	10.4	10.4–12.7	10.5–13.9	7.1–9.5
Trunk length	13.6	12.5–15.7	14.4–20.6	16.1–22.6
Tail length	75.6	75.0–75.6	67.9–72.1	69.8–74.9
Depth at gill opening	5.4	4.4–6.0	4.8–6.0	3.6–5.0
Depth at anus	4.9	3.4–5.6	3.3–6.3	2.2–5.9
% PAL				
Trunk length	55.6	49.2–57.8	52.4–66.2	63.4–80.0
Predorsal length	77.8	64.6–77.8	51.9–65.7	55.4–64.8
Head length	42.6	42.2–50.8	35.8–47.6	25.6–36.2
%HL				
Snout length	21.7	18.3–27.4	15.7–24.9	11.2–20.5
Eye diameter	12.8	8.3–14.9	8.7–15.3	10.0–18.7
Interorbital width	13.3	10.0–18.7	9.4–23.1	6.9–18.4
Upper jaw length	25.0	18.6–25.5	19.2–35.7	16.0–21.9
Lower jaw length	22.5	17.1–22.5	16.3–24.4	10.4–15.2
Gill opening	14.8	7.7–14.8	7.4–13.6	3.9–6.7
Interbranchial width	38.7	19.7–38.7	25.3–39.7	22.9–46.8
Pectoral-fin length	52.8	38.3–53.3	40.6–68.4	42.4–74.5
Vertebrae				
Predorsal	16	12–16	12–15	14–20
Preanal	24	22–25	27–32	28–38
Total	128	125–135	147–154	173–183
Precaudal	33	31–38	40–46	45–54
Lateral-line pores				
Preanal	21	19–24	25–32	33–36
Predorsal	13	13–14	11–13	16–18
Pre-gill opening	5	5–6	5–7	5
Head pores				
Supraorbital	3	3	3	3
Infraorbital	5	5	5	5
Mandibular	2	2	3	2
Preopercular	3	3	3	3
Supratemporal	0	0	0	1
Fin rays				
PADR	22	19–26	30–44	39–42
PR	12	12–13	10–15	11–14

Karrer (1983:48) recorded a single large *Macrocephenchelys brachialis* specimen (MNHN 1979-68, 703 mm TL) from the Mozambique Channel. It is the first and only record of *Macrocephenchelys* species from Indian Ocean. This specimen has a smaller eye than the Pacific specimens (6.5 vs. 10.0–18.7 % HL), which might indicate that it is specifically distinct. However, it is not certain how Karrer recorded that measurement. If she used the pigmented eye rather than the portion of the eye covered by the clear “spectacle,” then the recorded size would be smaller. In light of this uncertainty and the lack of comparative material, we retain this specimen in *Macrocephenchelys brachialis*. The Vanuatu specimen is a juvenile and does not show any significant differences from the more northern specimens.

Robins and Robins (1971:132) reported 182 vertebrae (expressed as 45 pre-caudal and 137 caudal) in the holotype, but Smith (1994:9) gave the total number as 179. We x-rayed the specimen again and counted 177 or 178. The uncertainty is caused by the 173rd vertebra, which appears to be double. Depending on whether this is counted as one or two vertebrae, the total count is 177 or 178. Based on the form of the hypural, the tail appears to be complete.

***Macrocephenchelys brevirostris* (Chen & Weng, 1967)**

Fig. 3B, 4, Table 1

Rhynchoconger brevirostris Chen & Weng, 1967:54, Fig. 40 (type locality: Dong-gang [also spelled Tung-kang, same pronunciation], southwestern Taiwan). Lectotype: NMMP 5177 (ex THUP 3078), designated by Ho *et al.* (2010:24); paralectotypes: NMMP 4181 (ex THUP 03236 and 03241). Smith, 1989:512; Smith, 1999:1685, 1686.

Macrocephenchelys brevirostris (Chen & Weng, 1967): Smith, 2000:586; Karmovskaya, 2004:S24; Ho *et al.*, 2010:23; Ho & Shao, 2011:24. Ho *et al.*, 2015:148.

Material examined (49 specimens, 199–460 mm TL). **Lectotype:** NMMP 5177, (1, 320), Dong-gang, Pingtung, Taiwan, 1 Aug. 1965. **Paralectotype:** NMMP 4181 (2, 282–293), Dong-gang, 1 May 1966. **Non-types:** **Daxi, Yilan, northeastern Taiwan:** ASIZP 60186 (1, 460), 15 Oct. 1997; ASIZP 60316 (1, 199), 14 Sep. 1998; ASIZP 63752 (5, 296–455), 24.58°N, 122.10°E, 250 m, beam trawl, 26 Aug. 2003; TOU-AE 6752 (1, mature male, 450), TOU-AE 6753 (1, mature female, 390), 16 Oct. 2012; TOU-AE 7046 (1, 417), 9 May 2012; USNM 441668 (1, 322), 27 Mar. 2004.

Nan-fang-au, Yilan, northeastern Taiwan: TOU-AE 6741 (1, mature female, 450), TOU-AE 6742 (1, mature female, 425), 14 Feb. 2012; TOU-AE 6901 (1, mature female, 453), 19 Oct. 2012. **Dong-gang, Pingtung, southwestern Taiwan:** ASIZP 62152 (1, 268), 300 m, 28 Jan. 2001; ASIZP 64098 (2, 335–352), 22.19°N, 120.38°E, 23 Nov. 2001; ASIZP 65226 (1, 368), 28 Apr. 2005; ASIZP uncat. (14, 225–367), 12 Sep. 2009; TOU-AE 6847 (1, mature male, 299), 4 Feb. 2013; USNM 399860 (1, 364), 8 Nov. 2009; USNM 400341 (1, 346), 8 Nov. 2009; USNM 437354 (7, 273–335), 6 Nov. 2015. **Taiwan (no further data):** USNM 396131 (1, 350), 2009; USNM 399951 (1, 230), 2009; USNM 400340 (1, 362), USNM 437353 (1, 235), 2015.

Diagnosis. *Macrocephenchelys brevirostris* is distinguished from *M. brachialis* by its more robust body (DA 3.3–6.3 vs. 2.2–5.9%TL); greater head length (10.5–13.9 vs. 7.1–9.5%TL); more anterior dorsal-fin origin (over tip of pectoral fin vs. well behind fin); fewer vertebrae (147–154 vs. 173–183); 3 mandibular pores (vs. 2); no ST pore (vs. 1); the presence of fleshy papillae on lower jaw and dorsally on head; sensory pits ventrally on head and abdomen; and the color pattern, gray above and white below. It differs from *M. soela* by the more posterior dorsal-fin origin (over tip of pectoral fin vs. over middle of fin; Castle, 1990). It differs from *M. nigriventris* **sp. nov.** by the unpigmented belly (vs. a conspicuous patch of melanophores), a greater average preanal length (27.1–33.5 vs. 24.4–28.0 %TL), more pre-anal lateral-line pores (25–32 vs. 19–24), 3 mandibular pores (vs 2), and more total vertebrae (147–154 vs. 125–135).

Description. Measurements in % TL: PAL 27.1–33.5, Tail 67.9–72.1, TR 14.4–20.6, PDL 15.9–19.7, HL 10.5–13.9, DA 3.3–6.3. In % PAL: TR 52.4–66.2 %, PDL 51.9–65.7, HL 35.8–47.6. In % HL: S 15.7–24.9, E 8.7–15.3, IO W9.4–23.1, UJ 18.9–35.7, LJ 16.3–24.4, GO 7.4–13.6, IB 25.3–39.7, PL 40.6–68.4. Pores: PGLL 5–7, PDLL 11–13, PALL 25–32, SO 3, IO 4+1+0, POM 6 (3+3), ST 0. Fin rays: PADR 30–44, PR 10–15. Vertebrae: PDV 12–15, PAV 27–32, PCV 40–46, TV 147–154.

Body moderate, dorsal-fin origin over tip of pectoral fin. Small fleshy papillae on underside of snout, behind anterior nostril, along upper jaw to gill-opening, more abundant on surface of chin. Scattered small pit-like

structures ventrally on head and abdomen, presumably sensory in nature, starting from level of first lateral-line pore, 8 rows from ventral view on abdomen, and 4 rows on each side, approximately 70 sensory pits before anus on innermost row (the most ventral side).

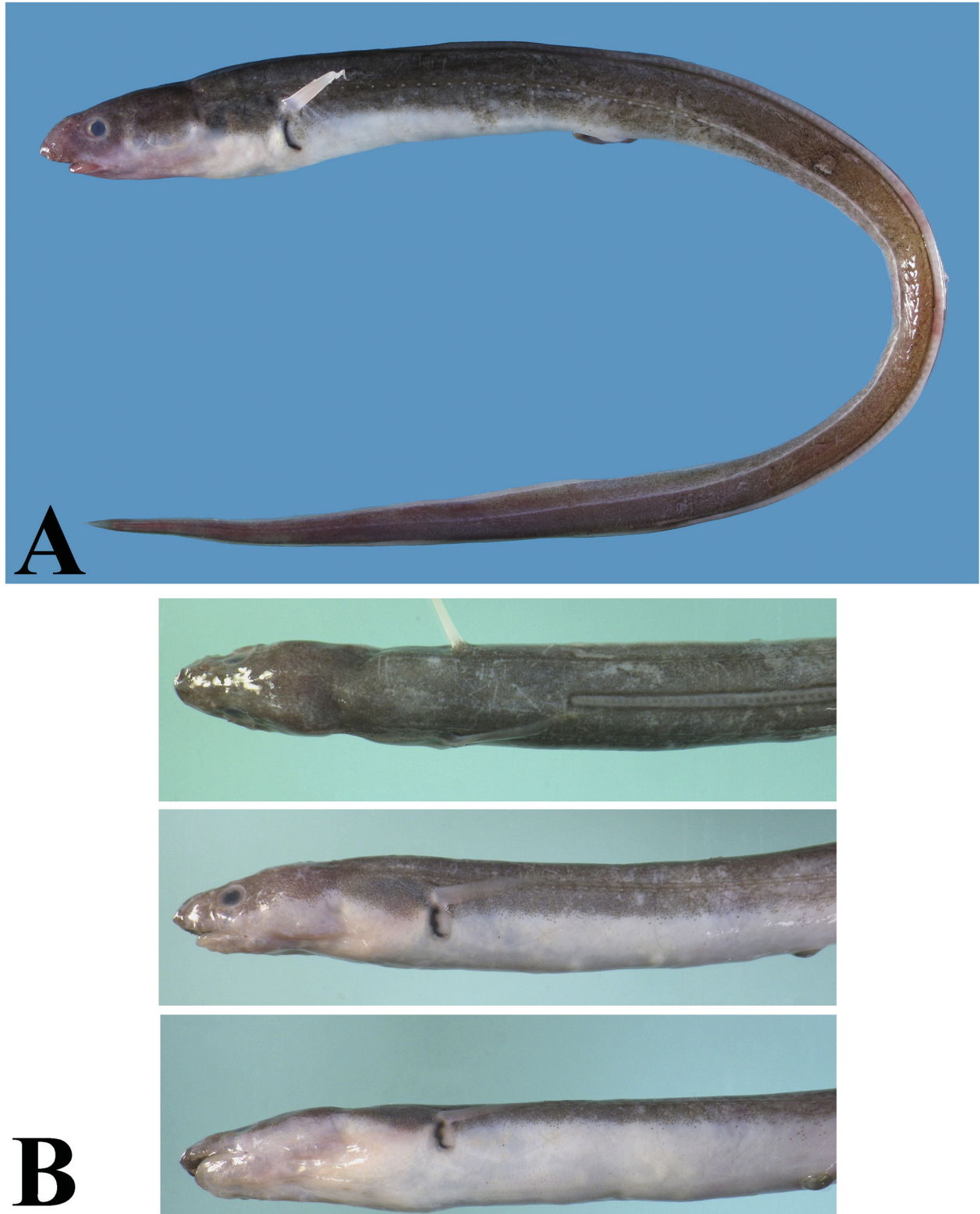


FIGURE 4. *Macrocephenchelys brevirostris*. A. USNM 439072, 330 mm TL, lateral view. B. TOU-AE6847, 299 mm TL, head and anterior body in dorsal, lateral, and ventral view.

Maxillary and dentary teeth small, conical, in several irregular rows, wider at anterior end; intermaxillary teeth conical, somewhat larger than maxillary and dentary teeth, in about 2 transverse rows; vomerine teeth in an oval patch, small and conical at anterior end, larger and molariform in middle and posterior part, extending about halfway to end of maxillary tooth row.

Distinctly bicolored, gray above and white below, without a patch of melanophores ventrally in front of anus; fins with white margin; gill cavity black.

Maximum size about 500 mm TL.

Remarks. *Macrocephenchelys brevirostris* and *M. nigriventris* resemble each other and are clearly distinguished from *M. brachialis* by the more robust body and head, more anterior dorsal-fin origin, and the presence of fleshy papillae on the head and small sensory pits on the underside of the body.

Distribution. Common around Taiwan, apparently in shallower water than *M. brachialis*. The type locality is Dong-gang in SW Taiwan; it is also collected at Da-xi and Nanfangao in NE Taiwan. The distribution beyond Taiwan is uncertain. It has been reported from the Philippines, Australia, and New Caledonia, (Karmovskaya, 2004), but it is not clear whether these all belong to the same species. Further studies are needed to determine how many species are present and what their distributions are.

Macrocephenchelys nigriventris new species

Fig. 3C, 5, 6, 7, Table 1

Holotype: TOU-AE 6893, 221 mm TL, mature female, with mature egg size 1 mm, Nan-fang-ao, Yilan, Northeastern Taiwan, at a depth of approximately 200 meters, 19 Jul. 2012.

Paratypes (27 specimens, 153–241). **Pingtung, southwestern Taiwan:** ASIZP 80331 (1, 189), Da-pong Bay, 5 Mar. 2003. NMMB-P 7094 (1, 233), Hsiao-liu-chiou, 180 m, 26 Dec. 2003. NMMB-P 7137 (1, 223), 26 Dec. 2003; NMMB-P 20976 (1, 205), 12 Mar. 2014; NMMB-P 21162 (1, 188), 2 Apr. 2014; NMMB 23961 (1, 220), 17 Feb. 2016; NMMB 24395 (1, 192), 24 Aug. 2016; NMMB 24396 (1, 198), 24 Aug. 2016; NMMB 24397 (1, 226), 24 Aug. 2016; NMMB 24741 (1, 180), 11 Oct. 2016; NMMB 24785 (1, 223), 7 Apr. 2016; TOU-AE 6846 (1, 202, mature female), 4 Feb. 2013; USNM 402449 (2, 193–200), Nov. 2009; USNM 437355 (3, 153–220), 28 Sep. 2013; USNM 437356 (1, 223), 2 Oct. 2015; USNM 437357 (4, 210–241), 6 Nov. 2016; USNM 438232 (1, 168), 2009; all collected from off Dong-gang fishing port.

Yilan, northeastern Taiwan: TOU-AE 6754 (1, mature female, 216 mm), Da-xi, Yilan, NE Taiwan, 16 Oct. 2012; TOU-AE 7228 (1, 212); USNM 268811 (1, 207), Da-Xi, Taiwan, 30 Sep. 1969; all collected from off Daxi fishing port. TOU-AE 6894 (1, mature female, 180 mm), Nan-fang-ao, 19 Jul. 2012.

Diagnosis. *Macrocephenchelys nigriventris* resembles *M. brevirostris* and *M. soela* in its more robust body and the presence of fleshy papillae on the head and sensory pits on the ventral surface of head and body. It differs from both in having a conspicuous patch of melanophores around the anus. It further differs from *M. brevirostris* in a lesser preanal length (24.4–28.0 %TL vs. 27.1–33.5), fewer pre-anal lateral-line pores (19–24 vs. 25–32), 2 mandibular pores (vs. 3), and fewer vertebrae (125–135 vs. 147–154). It differs from *M. soela* in the more posterior dorsal-fin origin (over tip of pectoral fin vs. middle of pectoral fin) and the number of vertebrae (125–135 vs. 151). It is the smallest of the known species; the largest specimen is 241 mm TL vs. 703 in *M. brachialis*, 460 in *M. brevirostris*, and 300 in *M. soela*; mature females were found as small as 180 mm.

Description. Measurements in percent %TL: PAL 24.4–28.0, Tail 75.0–75.6, TR 12.5–15.7, PDL 16.7–19.8, HL 10.4–12.7, DGO 4.4–6.0, DA 3.4–5.6. In %PAL: TR 49.2–57.8, PDL 64.6–77.8, HL 42.2–50.8. In % HL: S 18.3–27.4, E 8.3–14.9, IOW 10–18.7, UJ 18.6–25.5, LJ 17.1–22.5, GO 7.7–14.8, IB 19.7–38.7, PL 38.3–53.3. Pores: PALL 19–24, PDL 13–14, PGLL 5–6. SO 3, IO 4+1+0, POM 5 (2 + 3), ST 0 (one paratype, TOU-AE 6754, has 1 pore near first lateral-line on the left side of ST canal). Fin rays: PADR 19–26, PR 12–13. Vertebrae: PDV 12–16, PAV 22–25, PCV 31–36, TV 125–135.

Body moderate, cylindrical anteriorly, laterally compressed posteriorly, tail slender but not greatly attenuate. Anus located anteriorly, before mid-body, preanal distance about one fourth TL. Pectoral fin well developed, slender, the end of pectoral fin reaching level of dorsal-fin origin. Dorsal fin confluent with anal fin and caudal fin; origin of dorsal fin behind gill-opening, at mid-length of trunk and above tip of pectoral fin; fin height about one fourth body depth. Caudal fin moderately developed. Gill opening lateral, upper edge close to lateral-line.

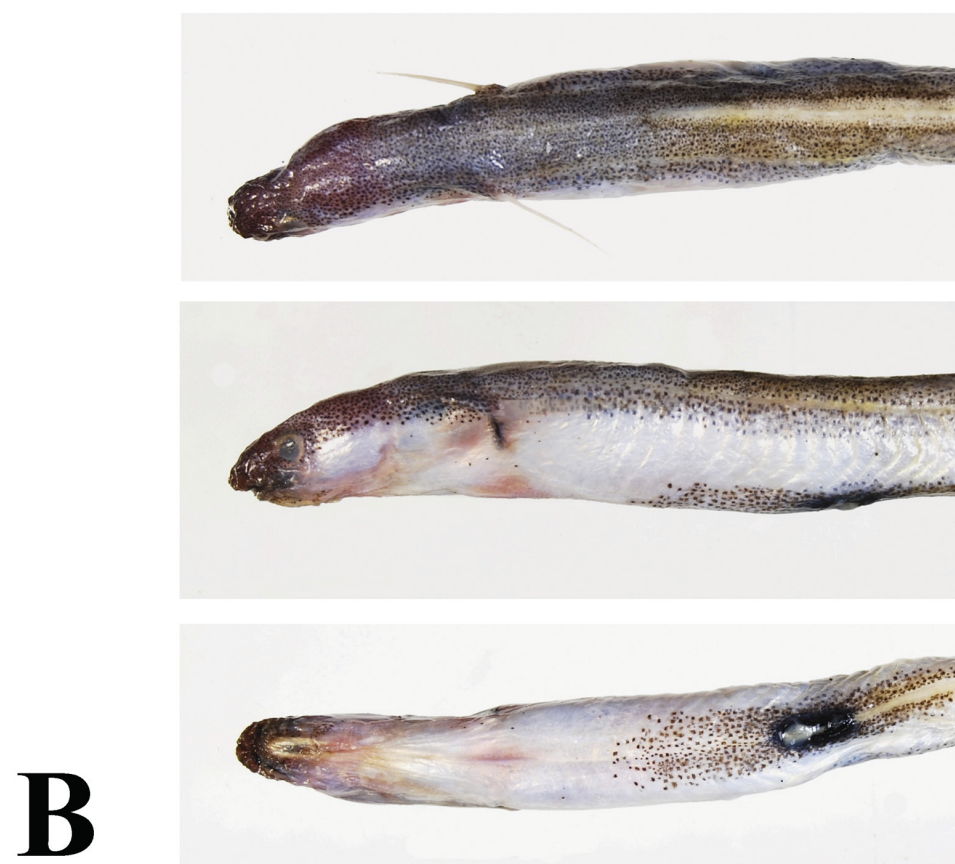


FIGURE 5. *Macrocephenchelys nigriventris* sp. nov., TOU-AE 6893, holotype, 221 mm TL. A. lateral view. B. head and anterior body in dorsal, lateral, and ventral view.

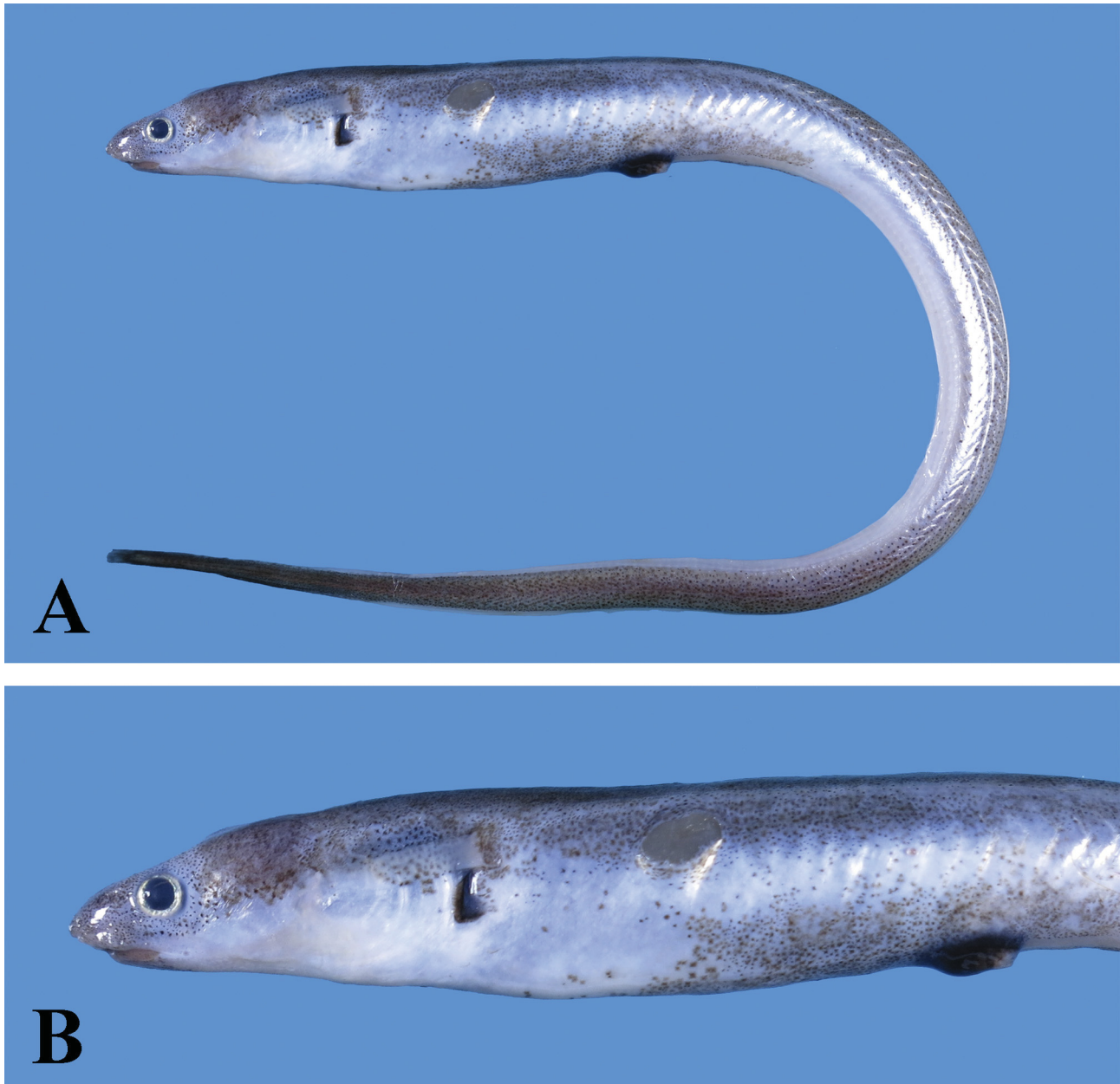


FIGURE 6. *Macrocephenchelys nigriventris*, NMMB-P24395, 190 mm TL. A. lateral view. B. lateral view of head.

Head short, bulbous. Snout blunt, swollen, length greater than eye diameter (E 52.9–66.1 % of S), tip soft and fleshy. Upper jaw longer than lower jaw. Small fleshy papillae on underside of snout, behind anterior nostril along upper jaw, on cheek below eye level, surface of chin, and beyond eye almost to level of gill opening. Eye moderate in size, round. Rictus reaching to or slightly behind level of anterior margin of eye. Anterior nostril tubular, just behind tip of snout, opening anterolaterally; posterior nostril elliptical, located before anterior margin of eye slightly above mid-eye level.

Maxillary and dentary teeth small, conical, multiserial, rows wider at anterior end; intermaxillary teeth conical, somewhat larger than maxillary and dentary teeth, in about 2 transverse rows; vomerine teeth in a short oval patch, small and conical at anterior end, blunter in middle and posterior part, extending less than halfway to end of maxillary tooth row (Fig. 7).

Cephalic sensory pores small, inconspicuous. Three SO pores: first on underside of snout tip, second directly above, third above and behind second at level of anterior nostril. ST pore absent except one paratype, TOU-AE 6754, which has a single pore on left side of canal, near lateral line. IO canal with five pores: first pore adjacent to base of anterior nostril; second and third pores relatively close together on lobe-like part of upper lip; fourth pore at

posterior end of upper lip; fifth pore behind rictus, below middle of eye; no pores behind eye. Five POM pores, two on mandibular section and three on preopercular; first and second pores on fringe of lower lip at anterior end of lower jaw; third, fourth and fifth pores tubular, evenly distributed behind posterior edge of eye to mid-way between eye and gill-opening, the fifth pore below level of first lateral-line pore. Many small, round pit-like structures on ventral part of throat and abdomen to level of anus; set in 8 rows from ventral view, 4 rows on each side; about 20 pores before gill-opening and approximately 70 pores to anus in the innermost row.

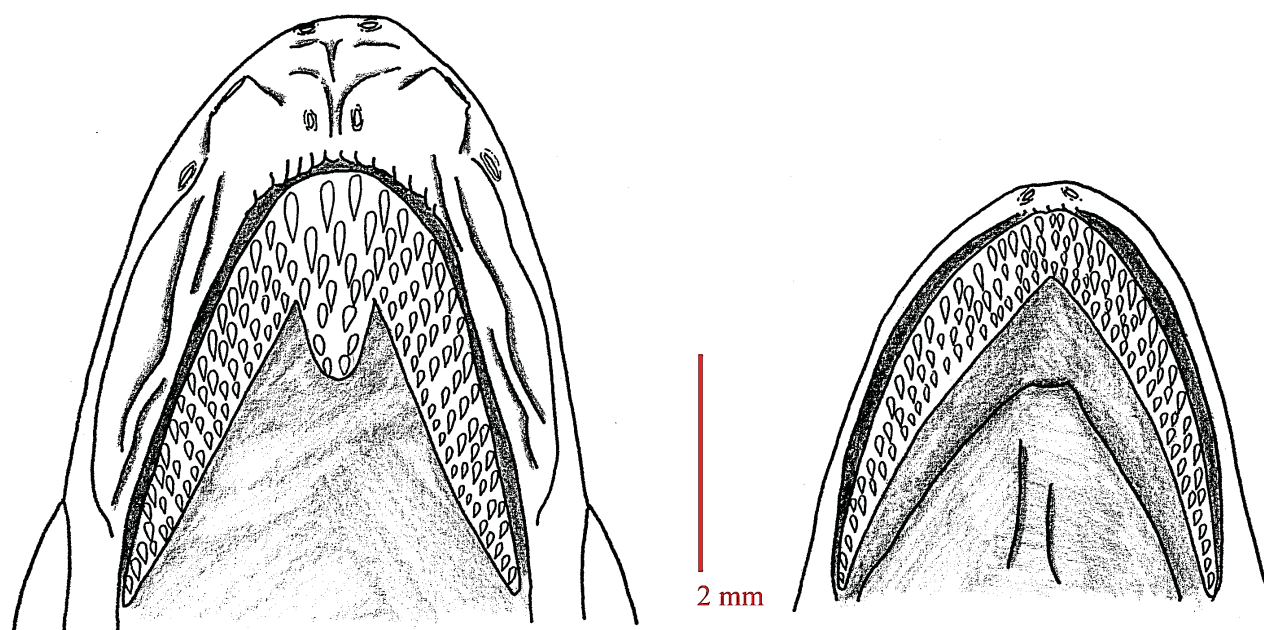


FIGURE 7. *Macrocephenchelys nigriventris*, TOU-AE6754, paratype, 216 mm TL, upper and lower jaw dentition.

Fresh specimens dark above and mostly pale below with silver skin (Figs. 5, 6). Dorsal part of head, body and tail densely covered with relatively large melanophores; posteriorly on tail the melanophores descend to ventral margin, covering entire tail. Anus surrounded by intense black pigment; a dense patch of melanophores on posterior half of abdomen in front of anus, extending about an equal distance behind anus on each side of anal fin. Head and tail with a hint of purple color. Oral and gill cavity black. Vertical fins transparent anteriorly, and black posteriorly to caudal fin, with a white margin.

Etymology. From the Latin, *nigri*-, black, dark, and *-ventris*, under side, belly, referring to the conspicuous black pigment on the posterior abdomen and anus.

Distribution. Twenty eight specimens known from northeastern and southwestern Taiwan. Four specimens are adult females with mature ovary and eggs at small body size (180–221 mm).

Remarks. One specimen from USNM 402449 had a more posterior dorsal-fin origin than any of the other specimens: predorsal length 23.1 % TL and 84.2% PAL and 20 predorsal vertebrae. The highest value for these characters in the other specimens were 19.0, 77.8, and 16 respectively. No other differences were apparent, and the posterior dorsal-fin origin seems to be an anomaly.

DNA Analysis. Partial COI sequences were obtained for the mitochondrial genes. The neighbor-joining phenetic tree (Fig. 8) was generated by the MEGA 5, based on a Kimura 2-parameter (K2P) model in 10,000 bootstraps. The tree shows that *M. brachialis*, *M. brevirostris*, and *M. nigriventris* belong to three separate clades. Within the phenetic tree, the mean pairwise distance is 7.1 % (SE=0.007; minimum distance of 0.00, and maximum distance of 14.4 %, n=13).

The *M. brachialis* clade differs from the *M. brevirostris* clade by 14.1 % on average (SE=0.016; minimum distance of 13.7 % and maximum distance of 14.3 %). The *M. brevirostris* clade differs from the *M. nigriventris* clade by 10.1 % on average (SE=0.014; minimum distance of 9.6 % and maximum distance of 10.6 %). The *M.*

brachialis and *M. nigriventris* clades differ by 13.9 % on average (SE=0.017; minimum distance of 13.7 % and maximum distance of 14.4 %).

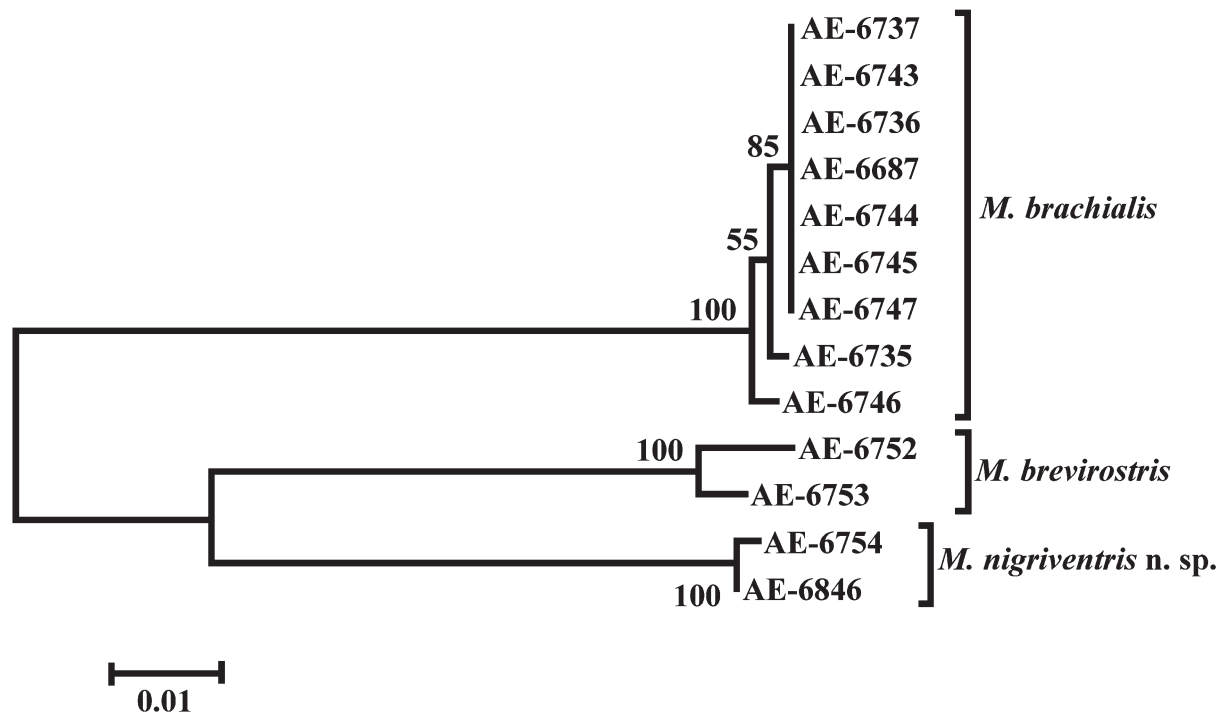


FIGURE 8. Neighbor-joining tree for three species of *Macrocephenchelys* from Taiwan.

Key to the known species of *Macrocephenchelys*

- 1a. Dorsal-fin origin well behind tip of pectoral fin, by a distance greater than pectoral-fin length; head short, less than 10%TL; ST pore present; no fleshy papillae on head; no sensory pits on abdomen; vertebrae more than 170 *M. brachialis*
- 1b. Dorsal-fin origin over pectoral fin or slightly behind, by a distance of less than pectoral-fin length; head longer, more than 10%TL; ST pore absent; fleshy papillae on head and sensory pores on abdomen present; vertebrae fewer than 160 2
- 2a. Dorsal-fin origin over middle of pectoral fin *M. soela* (Australia)
- 2b. Dorsal-fin origin over or slightly behind tip of pectoral fin 3
- 3a. Bicolored, gray above and white below, without a patch of pigment around anus and on abdomen; PAL 27–34%TL; vertebrae 147–154 *M. brevirostris*
- 3b. Bicolored but with a conspicuous patch of pigment around anus and on abdomen; PAL 24–28%TL; vertebrae 125–135 *M. nigriventris* sp. nov.

Acknowledgments

We are grateful to J.-F. Huang for preparing the figures and Y.-J. Chiou for preparing the line drawings; H.-C. Ho (NMMB-P) for various help in preparing the manuscript; and P.-L. Lin (ASIZP) and for kindly lending the specimens to us, and to C.-H. Chang (BRCAS) for molecular technical assistance. We also thank H.-M. Chen for guidance and the colleagues in the Laboratory of Aquatic Ecology, National Taiwan Ocean University, for their assistance in collections, measurements and photographs.

References

- Böhlke, E.B. (1989) Methods and Terminology. In: Böhlke, E.B. (Ed.), *Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Marine Research*, 1 (Part 9), pp. 1–7.
- Castle, P.H.J. (1990) Two new species of the previously monotypic congrid eel genera *Poeciloconger* and *Macrocephenchelys*

- from eastern Australia. *Records of the Australian Museum*, 42 (2), 119–126.
<https://doi.org/10.3853/j.0067-1975.42.1990.109>
- Chen, J.T.F. & Weng, H.T.C. (1967) A review of the Apodal fishes of Taiwan. *Biological Bulletin Tunghai University Ichthyology Series*, 6, 1–86.
- Fowler, H.W. (1934) Descriptions of new fishes obtained 1907 to 1910, chiefly in the Philippine Islands and adjacent seas. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 85, 233–367.
- Gosline, W.A. (1952) Notes on the systematic status of four eel families. *Journal of the Washington Academy of Sciences*, 12 (1), 130–135.
- Ho, H.-C. & Shao, K.-T. (2011) Annotated checklist and type catalog of fish genera and species described from Taiwan. *Zootaxa*, 2957, 1–74.
- Ho, H.-C., Smith, D.G., McCosker, J.E., Hibino, Y., Loh, K.-H., Tighe, K.A. & Shao, K.-T. (2015) Annotated checklist of eels (orders Anguilliformes and Saccopharyngiformes) from Taiwan. *Zootaxa*, 4060 (1), 140–189.
<https://doi.org/10.11646/zootaxa.4060.1.16>
- Ho, H.-C., Smith, D.G., Wang, S.-I., Shao, K.-T., Ju, Y.-M. & Chang, C.-W. (2010) Specimen catalog of Pisces collection of National Museum of Marine Biology and Aquarium transferred from Tunghai University and Aquarium. (II) Order Anguilliformes. *Platax*, 6, 13–34.
- Ivanova, N.V., Zemlak, T.S., Hanner, R.H. & Hebert, P.D.N. (2007) Universal primer cocktails for fish DNA barcoding. *Molecular Ecology Notes*, 7, 544–548.
<https://doi.org/10.1111/j.1471-8286.2007.01748.x>
- Karmovskaya, E.S. (2004) Benthopelagic bathyal conger eels of families Congridae and Nettastomatidae from the western tropical Pacific, with descriptions of ten new species. *Journal of Ichthyology*, 44 (Supplement 1), S1–S32.
- Karrer, C. (1983) Anguilliformes du Canal de Mozambique (Pisces, Teleostei). *Faune Tropicale*, 23, 1–116.
- Kimura, M. (1980) A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. *Journal of Molecular Evolution*, 16, 111–120.
<https://doi.org/10.1007/BF01731581>
- McCosker, J.E., Böhlke, E.B. & Böhlke, J.E. (1989) Family Ophichthidae. In: Böhlke, E.B. (Ed.), *Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Marine Research*, 1 (9), pp. 254–412.
- Robins, C.H. & Robins, C.R. (1971) Osteology and relationships of the eel family Macrocephenchelyidae. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 123, 127–150.
- Smith, D.G. (1989) Family Congridae. In: Böhlke, E.B. (Ed.), *Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Marine Research*, 1 (9), pp. 568–612.
- Smith, D.G. (1994) Catalog of type specimens of recent fishes in the National Museum of Natural History, Smithsonian Institution, 6: Anguilliformes, Saccopharyngiformes, and Notacanthiformes (Teleostei: Elopomorpha). *Smithsonian Contributions to Zoology*, 566, i–iii + 1–50.
<https://doi.org/10.5479/si.00810282.566.1>
- Smith, D.G. (1999) Congridae. In: Carpenter, K.E. & Niem, V.H. (Eds.), *FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific. Vol. 3. Batoid Fishes, Chimeras and Bony fishes, part 1 (Elopidae to Linophrynidae)*. FAO, Rome, pp. 1680–1687.
- Smith, D.G. (2000) Family Congridae. In: Randall, J.E. & Lim, K.K.P. (Eds.), *A checklist of the fishes of the South China Sea. The Raffles Bulletin of Zoology*, 8 (Supplement), pp. 569–667.
- Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M. & Kumar, S. (2011) MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. *Molecular Biology and Evolution*, 28, 2731–2739.
<https://doi.org/10.1093/molbev/msr121>